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(54) **ARTIFICIAL DURA**

(57) The present invention provides an artificial dura mater prepared from an biodegradable and bioabsorbable synthetic polymer sheet and having a total light transmittance of 30 % or more as defined by JIS K7105, a haze (cloudiness value) of 80 % or less as defined by JIS K7105 or a specular glossiness at 60° (Gs 60°) of 10-20 % as defined by JIS Z8741.

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**Description****TECHNICAL FIELD**

- 5 [0001] The present invention relates to an artificial dura mater to be used for prosthesis of dural defect in the field of neurosurgery and a method for treating the dural defect.

**BACKGROUND ART**

- 10 [0002] The dura mater occurring between the cranial bones and brain and covering the spinal cord protects the brain and spinal cord and inhibits leakage of cerebrospinal fluid. In the field of neurosurgery, a defect or contracture of the dura mater used to be filled with lyophilized products of human dura mater. However, the lyophilized products of human dura mater had drawbacks such as low homogeneity and short supply. Further, a possible transmission of infection of Creutzfeldt-Jacob disease through the use of the human dura mater was reported (Noshinkeigeka; 21(2), 167-170, 1993) and, eventually, the Japanese Ministry of Health and Welfare banned the use of the lyophilized product of human dura mater on April 7, 1997.

- [0003] To solve the above drawbacks, artificial dura mater made of silicone, for example, was developed. However, the silicone dura mater has fallen into disuse as it was reported that the silicone dura mater predisposed to meningorrhagia by remaining in vivo permanently because it was non-biodegradable, whereby being a chronic stimulant for the surrounding tissue to cause hypertrophy of the granulation tissue.

- 20 [0004] In contrast, artificial dura maters made of biodegradable and bioabsorbable materials such as collagen (Journal of Biomedical Materials Research; Vol. 25 267-276, 1991) and gelatin (No to Shinkei; 21 1089-1098, 1969) were produced, but they were not in practical use because of strength-related problems, i.e., because of the insufficiency in the suture strength to be sutured integrally with the internal dura mater.

- 25 [0005] The applicant provided, in Japanese Unexamined Patent Publication No. 8-80344, an artificial dura mater comprising a sheet made of a biodegradable and bioabsorbable polymer, for example, a copolymer of lactic acid and caprolactone and, further, an artificial dura mater comprising introducing a biodegradable and bioabsorbable polymer made of a material different from that of the sheet as a reinforcement between the sheets and integrally molding the sheets and the reinforcement.

- 30 [0006] An object of the present invention is to provide an artificial dura mater which allows to observe the brain surface therethrough after covering the operative field with the artificial dura mater.

- [0007] Another object of the present invention is to provide a method for treating aural defect.

**BRIEF DESCRIPTION OF DRAWINGS**

35

**[0008]**

Fig. 1 is a spectrum showing a total light transmittance of the artificial dura mater obtained in Example 1 of the present invention.

- 40 Fig. 2 is a spectrum showing a total light transmittance of e-PTFE manufactured by W.L.Gore & Associates, Inc. (GORE-TEX (registered trademark)).

Fig. 3 is a spectrum showing a total light transmittance of a lyophilized cadaveric dura mater manufactured by Tokibo (Tutoplast Dura (registered trademark)).

45 **DISCLOSURE OF INVENTION**

[0009] An artificial dura mater of the present invention is characterized by comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a total light transmittance of 30 % or more as defined by JIS K7105.

- 50 [0010] Further, an artificial dura mater of the present invention is characterized by comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a haze (cloudiness value) of 80 % or less as defined by JIS K7105.

[0011] Moreover, artificial dura mater of the present invention is characterized by comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a specular glossiness at 60° (Gs 60°) of 10-20 % as defined by JIS Z8741.

- 55 [0012] The present invention further provides a method for treating dural defect which comprises covering the dural defect by suturing the residual native dura mater integrally with an artificial dura mater according to any one of claims 1-7.

[0013] According to the invention. Examples of the biodegradable and bioabsorbable synthetic polymer are aliphatic polyesters (polyglycolic acid, polylactic acid, polycaprolactone, polyvalerolactone and copolymers thereof),

polyesterether (poly-1,4-dioxanone-2-one, poly-1,5-dioxepan-2-one, ethyleneglycol-said aliphatic polyester copolymer, propyleneglycol-said aliphatic polyester copolymer) and copolymers of the aliphatic polyester and polyesterether, preferably a copolymer of lactic acid (L form, D form, D,L form) and caprolactone, more preferably a copolymer of L-lactic acid and  $\epsilon$ -caprolactone.

5 [0014] The artificial dura mater of the invention has a total light transmittance of about 30 % or more, preferably about 50 % or more, more preferably about 70 % or more as defined by JIS K7105.

[0015] A haze (cloudiness value) of the artificial dura mater may preferably be about 80 % or less, more preferably about 70 % or less.

10 [0016] A specular glossiness at 60° (Gs 60°) of the artificial dura mater may preferably be about 10-20 %, more preferably be about 15-18 %.

[0017] Examples of a preferable artificial dura mater of the invention are an artificial dura mater having a total light transmittance of about 30 % or more as defined by JIS K7105 and a haze (cloudiness value) of about 80 % or less as defined by JIS K7105, especially an artificial dura mater having a total light transmittance of about 70 % or more and a haze (cloudiness value) of about 70 % or less.

15 [0018] The artificial dura mater of the invention may especially preferably have a total light transmittance of about 70 % or more, haze (cloudiness value) of about 70 % or less and a GS 60° of about 15-18 %.

[0019] If at least one of the total light transmittance, haze (cloudiness value) and GS 60° is in the above range, the sheet to be used is not limited to said biodegradable and bioabsorbable synthetic polymer sheet.

20 [0020] In addition, the artificial dura mater of the invention may be foamed or in the form of a porous film having micropores.

[0021] If the total light transmittance is lower than 30 % as defined by JIS K7105, it will be difficult to observe the brain surface through the resultant artificial dura mater. Also, if the haze (cloudiness value) is higher than 80 % as defined by JIS K7105, it will be difficult to observe the brain surface through the resultant artificial dura mater.

## 25 BEST MODE FOR CARRYING OUT THE INVENTION

[0022] The following example serves to illustrate the present invention. It is to be understood that the example is not restrictive of the present invention.

### 30 (Example 1)

#### 1. Production of Polymer

##### (1) Film (Sheet) Portion

35 [0023] L-lactide/ $\epsilon$ -caprolactone copolymer [molar ratio: 50 /50; weight average molecular weight by GPC: 150,000; hereinafter referred to as P (L-LA/CL) (molar ratio: 50/50)] was synthesized in a conventional manner.

##### (2) Reinforcement (Nonwoven Fabric) Portion

40 [0024] Polyglycolic acid (intrinsic viscosity = 1.18) was produced in a conventional manner.

#### 2. Production of Film (Sheet)

45 [0025] 1. P (L-LA/CL) (molar ratio: 50/50) obtained in (1) was dissolved in a solvent (chloroform) so that the resultant solution contains 5 wt% of P (L-LA/CL) (molar ratio: 50/50). After completion of dissolution, the solution was subjected to filtration to remove insoluble matter. The solution was then casted on a glass plate (flow casting) and subjected to an air drying, followed by a vacuum drying at 50°C for 12 hours to remove the solvent completely.

#### 50 3. Production of Reinforcement (Nonwoven Fabric)

[0026] 1. A nonwoven fabric was produced by spinning the polyglycolic acid obtained in (2) to obtain a polyglycolic acid yarn having 20 deniers, followed by drawing, and then circular knitting the drawn yarn and needle punching this knitting.

#### 55 4. Composite

[0027] An artificial dura mater having a three-layer structure (film thickness of 200  $\mu$ m) was produced by integrally

molding the reinforcement (nonwoven fabric) obtained in (3) with the films (sheets) obtained in (2) placed at both sides of the reinforcement by vacuum press at a temperature of 140°C and a pressure of 50 kg/cm<sup>2</sup>.

(Total Light Transmittance Test)

[0028] The artificial dura mater obtained in Example 1, e-PTFE (GORE-TEX (registered trademark)) and a lyophilized cadaveric dura mater (Tutoplast Dura (registered trademark)) respectively were cut into test pieces each having a size of 50 mm x 50 mm, and then the transmittance of each of the test pieces was measured by means of an automatic spectrophotometer (UV310PC, manufactured by Shimadzu Seisakusho). The measurement results are shown in Table 1 and Figs. 1-3.

Table 1

Wavelength (nm)	Test Piece		
	Example 1	e-PTFE	Cadaveric Dura Mater
350	71.7	2.4	0.1
550	74.2	3.9	2.3
850	90.0	6.3	7.0

[0029] Fig. 1 shows a transmittance spectrum of the artificial dura mater of the invention obtained in Example 1. Fig. 2 shows a transmittance spectrum of the e-PTFE (GORE-TEX (registered trademark)). Fig. 3 shows a transmittance spectrum of the lyophilized cadaveric dura mater (Tutoplast Dura (registered trademark)).

[0030] As is apparent from Table 1 and Figs. 1-3, the artificial dura mater of the invention have a good transmittance which allows to observe the brain surface therethrough.

(Haze (cloudiness value) Test)

[0031] The artificial dura mater obtained in Example 1, e-PTFE (GORE-TEX (registered trademark)) and a lyophilized cadaveric dura mater (Tutoplast Dura (registered trademark)) respectively were cut into test pieces each having a size of 50 mm x 50 mm, and then the hazes (cloudiness values) of each of the test pieces were tested in accordance with JIS K7105 using a direct-reading haze computer (HGM-2K manufactured by Suga Test Instruments Co., Ltd.). The measurement results are shown in Table 2.

Table 2

	Example 1	e-PTFE	Cadaveric Dura mater
Haze (Cloudiness Value)	63.3	98.4	99.2

(Specular Glossiness at 60° (Gs 60°) Test)

[0032] The artificial dura mater of the invention obtained in Example 1 was cut into a test piece having a size of 50 mm x 50 mm, and then the Gs (60°) of the test piece was measured in accordance with JIS Z8741 by using YGV-5K, a digital deformation glossmeter manufactured by Suga Test Instruments Co., Ltd. The Gs (60°) of the artificial dura mater of Example 1 was measured to be 17.

[0033] As explained above, according to the present invention, it is possible to observe the brain surface after covering the operative field with the artificial dura mater of the invention, and the artificial dura mater of the invention is sutured integrally with the internal dura mater easily since the internal dura mater can be observed through the artificial dura mater even during the operation.

#### Claims

1. An artificial dura mater which is characterized by comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a total light transmittance of 30 % or more as defined by JIS K7105.

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2. An artificial dura mater comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a haze (cloudiness value) of 80 % or less as defined by JIS K7105.
3. An artificial dura mater comprising a biodegradable and bioabsorbable synthetic polymer sheet, and having a specular glossiness at 60° (Gs 60°) of 10-20 % as defined by JIS Z8741.
4. The artificial dura mater according to any one of claims 1-3, wherein the biodegradable and bioabsorbable synthetic polymer is at least one selected from the group consisting of aliphatic polyesters (polyglycolic acid, poly(L form, D form, D,L form)lactic acid, polycaprolactone, polyvalerolactone and copolymers thereof), polyesterether (poly-1,4-dioxanone-2-one, poly-1,5-dioxepan-2-one, ethyleneglycol-said aliphatic polyester copolymer, propyleneglycol-said aliphatic polyester copolymer) and copolymers of the aliphatic polyester and polyesterether.
5. The artificial dura mater according to claim 4, which is characterized in that the biodegradable and bioabsorbable synthetic polymer is a copolymer of lactic acid and caprolactone.
6. The artificial dura mater according to any one of claims 1-5, which is characterized by having a three layer structure comprising integrally molding the sheets and a reinforcement prepared from a biodegradable and bioabsorbable synthetic polymer different from that of the sheets in such a manner that the reinforcement is sandwiched between the sheets.
7. The artificial dura mater according to claim 6, wherein the reinforcement comprises at least one selected from the group consisting of a lactide/ $\epsilon$ -caprolactone copolymer which is different from that of the sheet in the molar ratio, polyglycolic acid, polylactic acid and lactic acid/glycolic acid copolymer.
8. A method for treating a dural defect, comprising covering the dural defect by suturing an artificial dura mater according to any one of claims 1-7 with the residual native dura mater.

Fig. 1

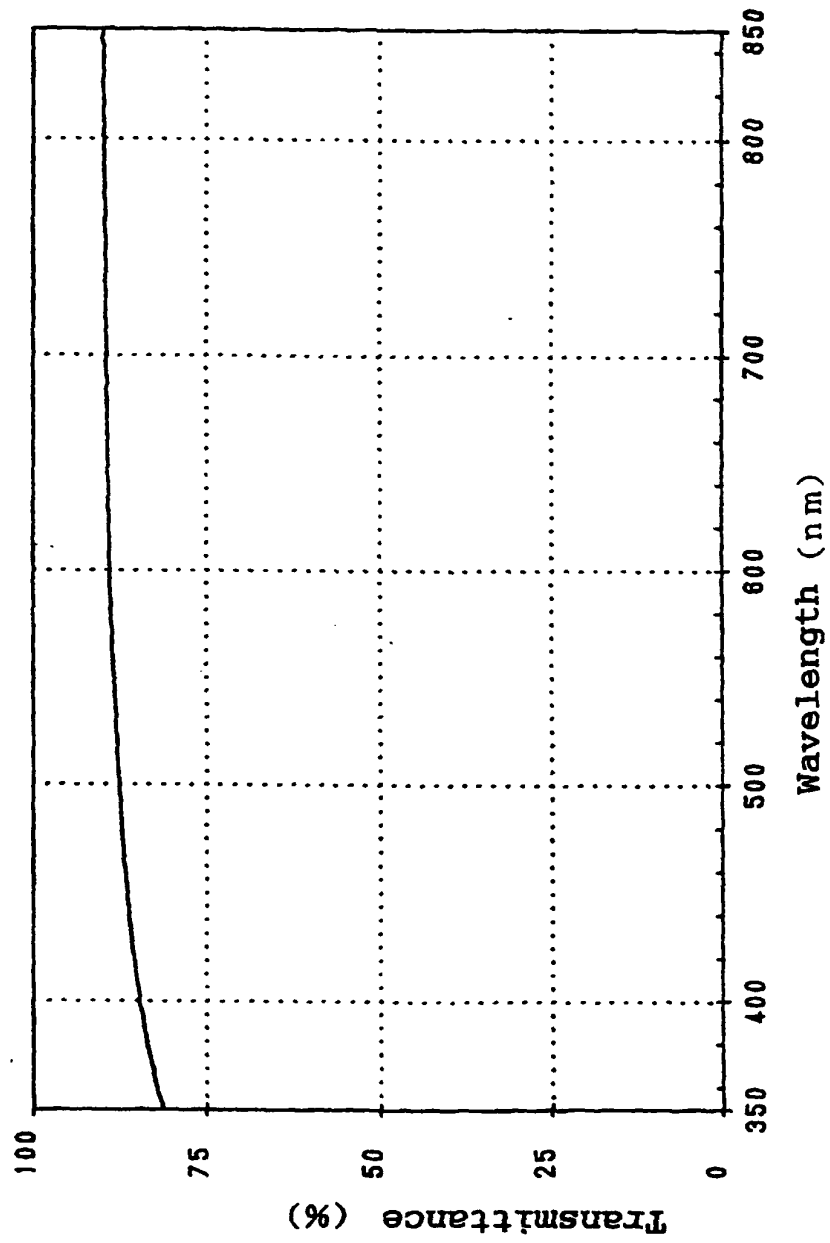


Fig. 2

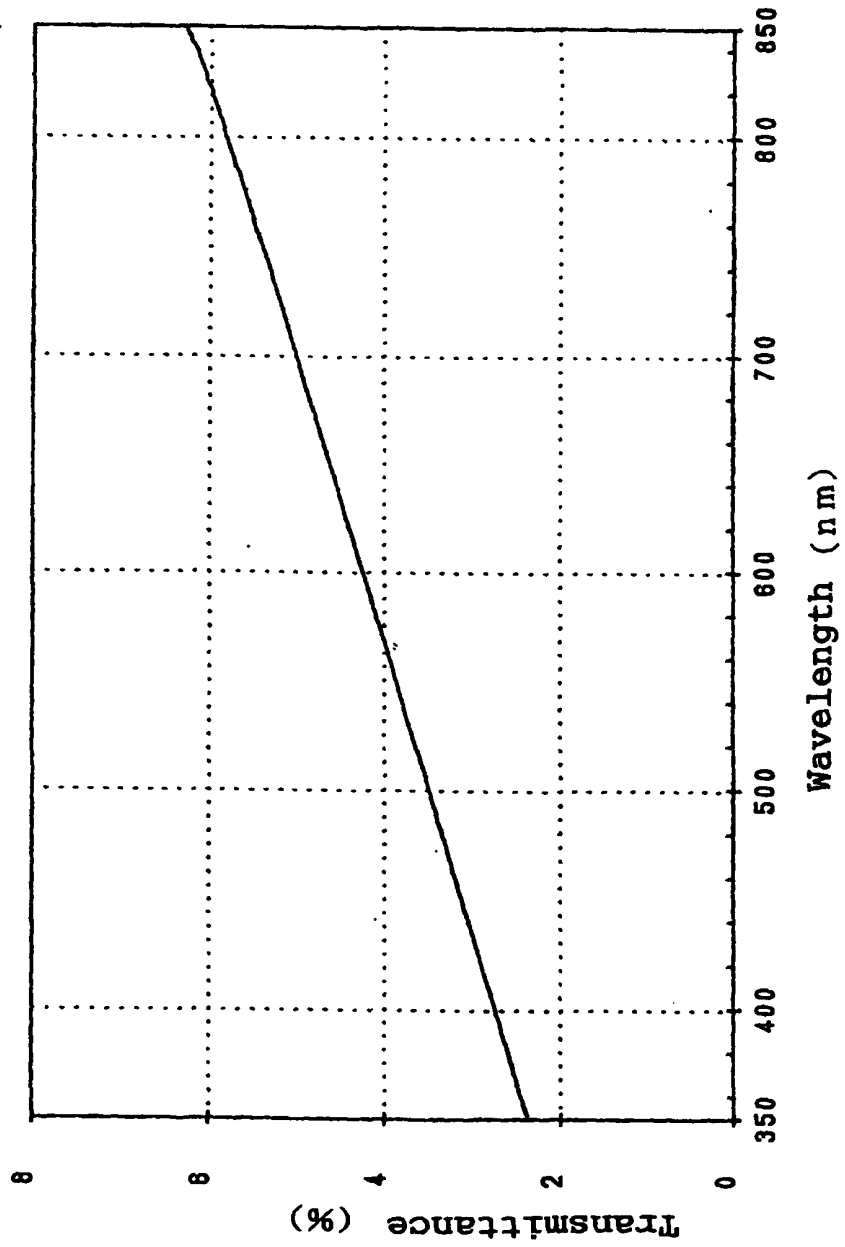
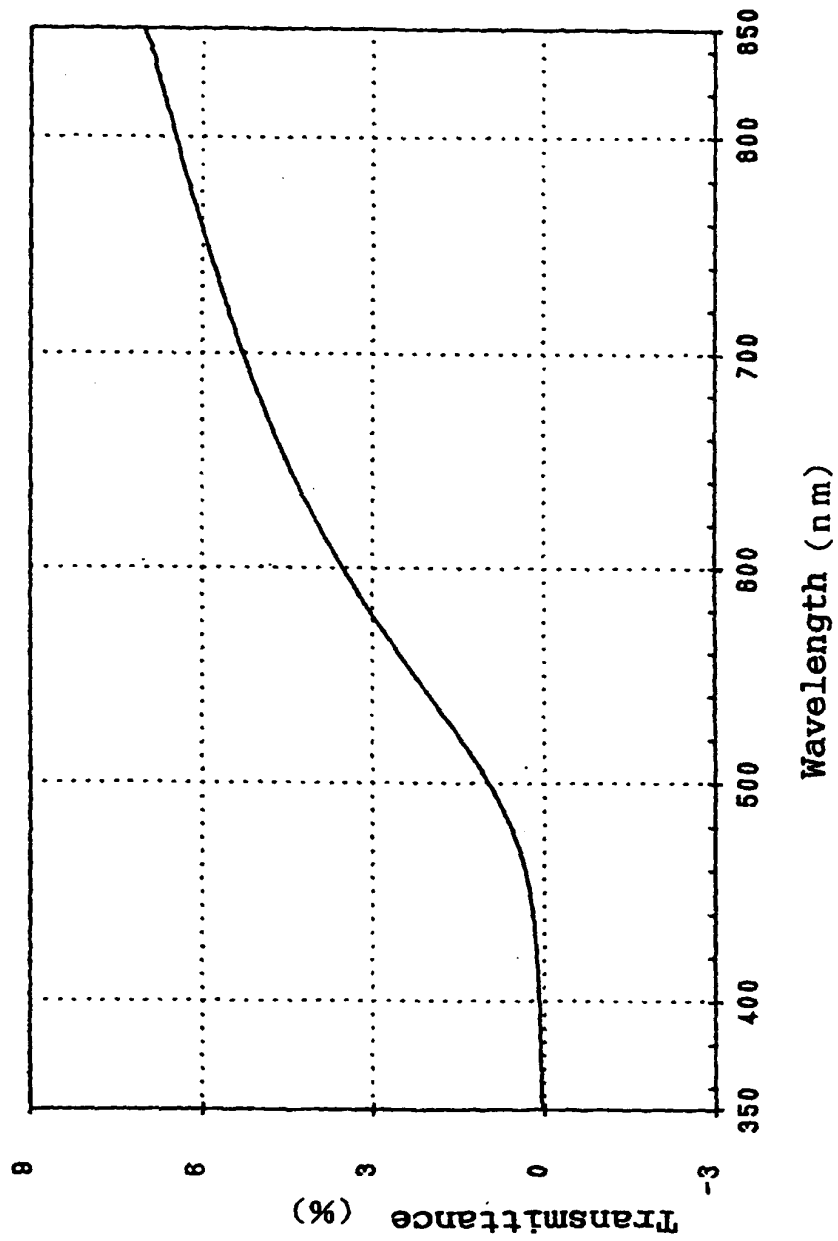


Fig. 3



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/04542

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int.Cl. <sup>6</sup> A61L27/00, A61F2/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl. <sup>6</sup> A61L27/00, A61F2/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 8-80344, A (Gunze Ltd.), 26 March, 1996 (26. 03. 96) (Family: none)	1-7
Y	JP, 2-152461, A (Yugengaisha Nippon Sogo Igaku Kenkyusho), 12 June, 1990 (12. 06. 90) (Family: none)	1-7
Y	JP, 3-505535, A (Blocon OY), 5 December, 1991 (05. 12. 91) & WO, 90/00410, A1 & EP, 423155, A	1-7
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 17 December, 1998 (17. 12. 98)		Date of mailing of the international search report 6 January, 1999 (06. 01. 99)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/04542

**Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 8  
because they relate to subject matter not required to be searched by this Authority, namely:  
  
Claim 8 relates to an invention of methods for treatment of the human body by therapy.
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1992)